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Canadian Science Advisory Secretariat
Newfoundland and Labrador Region | Science Advisory Report 2018/053

STOCK ASSESSMENT OF WITCH FLOUNDER (*GLYPTOCEPHALUS CYNOGLOSSUS*) IN NAFO DIVISIONS 2J3KL

Image. Witch Flounder (Glyptocephalus cynoglossus).

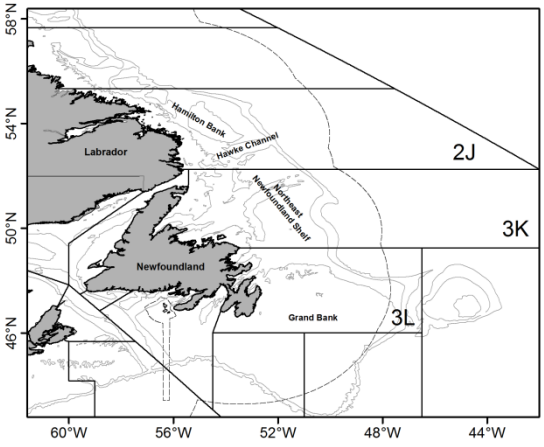

Figure 1. NAFO Divisions 2J3KL.

Context:

Witch Flounder (Glyptocephalus cynoglossus) is a deepwater flatfish that reaches its northern limit of distribution in the Northwest Atlantic near Hamilton Bank off Labrador, and extends to the east coast of the southern United States of America. In the Northwest Atlantic Fisheries Organization (NAFO) Divisions (Divs.) 2J3KL, this species is primarily distributed along the shelf edge and in deeper channels around the banks, primarily in Div. 3K. The fishery for Witch Flounder in NAFO Divs. 2J3KL began in the early-1960s, and peaked in the early-1970s.

Canada has managed Witch flounder in NAFO Divisions 2J3KL since the establishment of the Canadian Exclusive Economic Zone (EEZ). At the 1997 NAFO Annual Meeting, NAFO adopted a Canadian proposal to implement a moratorium on 3L Witch Flounder in the NAFO Regulatory Area (NRA) consistent with the management measures taken by Canada in 1995 as the coastal state. The stock has remained under moratoria and NAFO has maintained management measures consistent with Canadian management measures for Division 3L within the NAFO Regulatory Area.

This stock is currently assessed by NAFO Scientific Council (SC) on a 3-year schedule, with the most recent full assessment of this stock by SC occurring in 2016 (Maddock Parsons et al. 2016). In 2018, DFO Science was asked by Resource Management Branch (NL Region) to provide an assessment of stock status, and to determine a limit reference point within the DFO decision-making framework. The present assessment is the result of this request for science advice. Participants included Fisheries and Oceans Canada (DFO) scientists and fisheries managers, an Indigenous group, a representative from the provincial government of NL, academia, and fishing industry representatives.

This Science Advisory Report is from the May 9, 2018 2J3KL Witch Flounder Stock Assessment. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- This stock has been under moratorium in Canadian waters since 1995, and in the NAFO regulatory area since 1998. Bycatch of Witch Flounder has been relatively stable, averaging 174 t annually from 2013-17, primarily taken in the Canadian Greenland Halibut fishery.
- This stock is assessed using fall DFO research vessel (RV) survey indices. In 2016 and 2017, indices of abundance and biomass reached the highest levels since 1990, but remained below the levels of the mid-1980s.
- The abundance index of fish <23 cm indicate improved recruitment since 2013.
- Following a contraction of the stock to shelf slope areas through the 1990s, the distribution of the stock has expanded in recent years, returning to deep channels occupied in the mid-1980s.
- A proxy for B_{MSY} was accepted as the mean of the survey biomass indices from the 1983-84 fall RV surveys. Consistent with the DFO decision-making framework incorporating the precautionary approach, a Limit Reference Point (LRP) of 40% B_{MSY} was adopted. The stock is currently in the critical zone.
- A variable proportion of the population inhabits the deep water of Div. 3L which has only been surveyed in 3 of the last 10 years. In years with incomplete coverage the survey index may underestimate stock size. The magnitude of this cannot be determined, but is not considered to impact stock status relative to the LRP.

BACKGROUND

Oceanography and Ecosystem Overview

Physical Environment

Ocean temperatures have been generally above normal for the past decade, reaching highs in 2006, declining to more normal values in 2007-09, then increasing to record highs in 2011, before trending lower through 2017. A standardized climate index derived from 28 meteorological, ice, water mass areas, and ocean temperature and salinity time-series has been trending downward since the near-record highs of 2010 and 2011 to mostly below normal values (cold/fresh) during the past four years. The impact of these oceanographic changes on Witch Flounder population dynamics is difficult to determine.

Ocean Productivity

Seasonal surveys along the standard sections across Divs. 2J3KL indicate reduction in inventories of macronutrients in 2017 and recent years, coinciding with a reduction in phyto- and zooplankton biomass during the same time period. The reduction in zooplankton biomass is linked to a shift in its community composition with increased abundances of smaller taxa (e.g. *Pseudocalanus* spp.), and declines of energy-rich large taxa (e.g. *Calanus finmarchicus)*. These changes observed in lower trophic levels and community composition of zooplankton indicate reduced primary and secondary inputs that may impact transfer of energy to higher trophic levels in recent years.

Marine community

During the late-1980s and early-1990s the marine community in the NL bioregion collapsed. This collapse can be associated to a combination of historical overfishing, and a regime shift.

Changes were more dramatic in the northern regions and involved commercial and non-commercial species. It was also during this period that increases in shellfish species (e.g. Northern Shrimp *Pandalus borealis*) occurred.

During 2004-10 there was an increasing trend in the finfish biomass in Divs. 2J3KL; with many components of the community (e.g. piscivores such as Atlantic Cod *Gadus morhua*, and Greenland Halibut *Reinhardtius hippoglossoides*; large benthivores like American Plaice *Hippoglossoides platessoides*, and plank-piscivores like redfish *Sebastes* spp) showing positive signals. These were the first significant increases observed in the finfish component of this marine community since the collapse, and coincided with an increase in Capelin *Mallotus villosus* biomass. Medium benthivores (e.g. Blue Hake *Antimora rostrata,* Yellowtail Flounder *Limanda ferruginea*, and including Witch Flounder *Glyptocephalus cynoglossus*) make up a small fraction of the survey biomass. While finfish were building-up, total shellfish biomass started to decline in 2007-08. Total finfish biomass remained fairly stable during the early-2010s at levels still well below pre-collapse levels, but showed signals of decline by 2013-14 that have continued to the present. This recent decline may be linked to decreases in capelin and shrimp availability as well as other changes in ecosystem conditions which indicate reduced ecosystem productivity.

Species Biology

Witch Flounder is a long lived, right-eye flounder found across the North Atlantic, with distribution in the west that extends from Labrador to North Carolina. In Divs. 2J3KL, individuals have been aged to over 30 years old, but the number of age groups in this area was substantially reduced from the mid-1970s to early-1980s, with fish older than 15 years rarely seen in the survey or fishery catch in later years. Aging information has been unavailable for this stock since 1994.

Witch Flounder are most commonly associated with shelf slope waters and deeper channels, but are present at a wide range of depths, from <100 m to well over 1,000 m. This species prefers soft substrates such as sand, clay or mud. Historically, the highest abundance of Witch Flounder in Divs. 2J3KL was found in the Hawke Channel (Bowering 1987).

Spawning of Witch Flounder in the Northwest Atlantic occurs over a prolonged period from March through to September, but with the highest intensity in Divs. 2J3KL considered to be from March to May. This species forms dense pre-spawning and spawning aggregations, with offshore fisheries historically targeting these concentrations (Bowering 1995).

The Fishery

The fishery for Witch Flounder in NAFO Divs. 2J3KL began in the early-1960s and increased steadily from about 1,000 t in 1963 to a peak of over 24,000 t in 1973 (Fig. 2), with the fishery targeting pre-spawning concentrations (Bowering 1979). The regulated fishery began in 1974 with a TAC of 22,000 t. Catches declined rapidly, with 2,800 t by 1980, and subsequently fluctuated between 3,000 and 4,500 t to 1991. Landings declined further to 137 t by 1994. A moratorium on directed fishing of this stock was put in place within Canadian waters (within 200 nm) in 1995, and extended to the NAFO regulatory area in 1998. There has been no directed fishing since this time. During the height of the fishery from the mid-1960s to late-1980s, fishing was conducted mainly in Div. 3K (Fig. 2) primarily by Poland, the Union of Soviet Socialist Republics (USSR), and Canada.

Since 1998, landings from bycatch ranged from 68 to 633 t, averaging 182 t annually across the last five years (2013-17), primarily caught in the Canadian Greenland Halibut fishery. Logbook

records indicate that recent catches have been predominantly from the slope of the Northeast Newfoundland Shelf in Div. 2J and the northeast slope of the Grand Bank (Div. 3L). Available length measurements from at-sea observers and port sampling of commercial otter trawl fisheries show Witch Flounder from 30-60 cm make up the bulk of recent bycatch landings. However, sampling effort is low, with 0-20 length frequencies recorded annually since 2000.

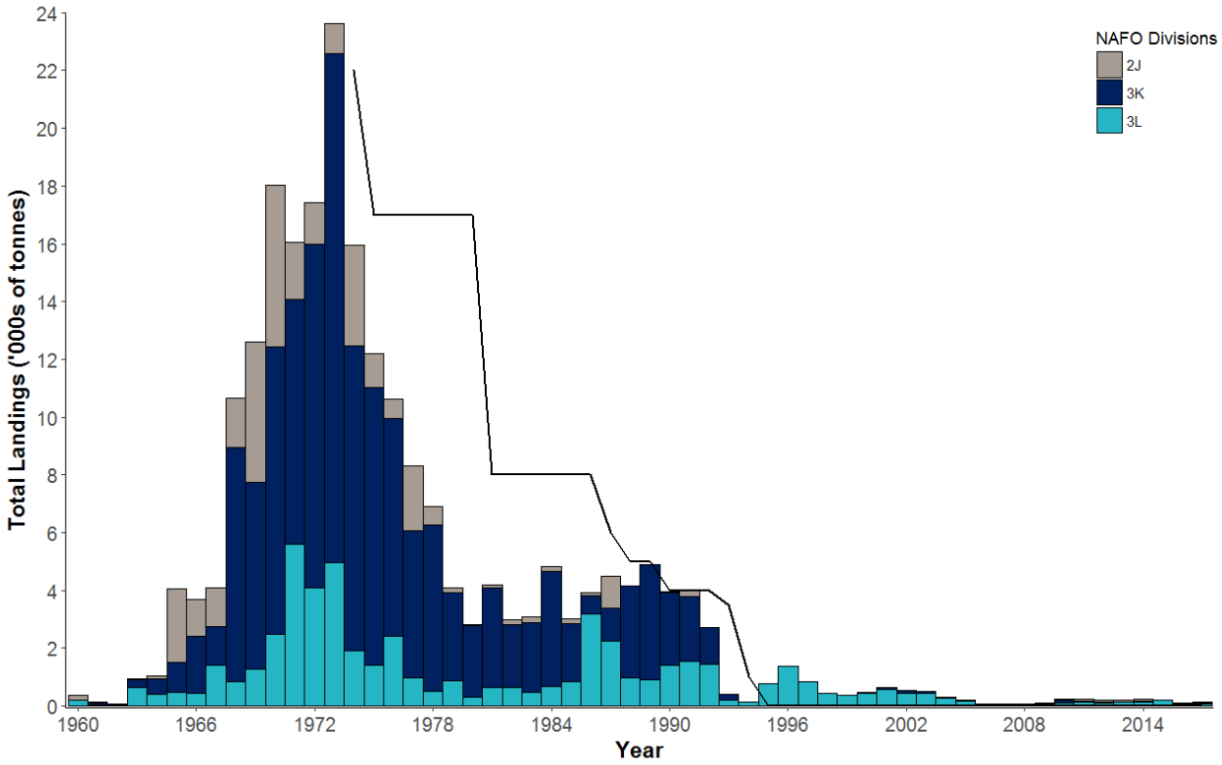

Figure 2. NAFO-reported Landings (STATLANT21A) by NAFO Division and TAC, 1960-2017. This stock has been under moratorium in Canadian waters since 1995, and in the NAFO regulatory area since 1998.

ASSESSMENT

Fall Research Vessel (RV) survey (1983-2017)

Stratified-random RV surveys have been conducted in the fall in Divs. 2J, 3K and 3L since 1977, 1978 and 1981 respectively. Campelen equivalent data are available for all three divisions starting in 1983, therefore indices used in this assessment are from 1983-2017. Details of the stratified random trawl survey design and changes in gear, including the introduction of the Campelen trawl in 1995, are described in previous documents (see Brodie and Stansbury 2007, Brattey et al. 2008, and references therein).

Surveys prior to 1996 covered only a part of the stock area, with limited coverage of inshore and deep areas. As such, estimates of biomass and abundance from the early part of the survey series are most likely underestimated. Deep strata (>1,000 m in Divs. 2J, 3K; >730 m in Div. 3L) were introduced to the survey throughout Divs. 2J3KL in 1996. Coverage of deep water in Div. 3L has been inconsistent in recent years, with complete coverage of this area in just four years since 2004 (2007, 2009, 2010, 2014). In addition, the majority of deep strata in Divs. 2J and 3K were also incomplete in 2008. A series of inshore strata along the eastern coast of

Newfoundland were also added to the survey in 1996, and were consistently covered to 2006 (1999 excluded). However, these have been largely incomplete in each year from 2007-09 and 2011-17. Further details of survey performance statistics, timing, and spatial coverage are summarized in Rideout et al. 2017 and references therein.

Age data from Witch Flounder in the DFO RV surveys have not been available since 1994. This precludes the use of any age-based assessment tools to evaluate stock parameters such as mortality, growth, and maturity rates.

Abundance and **biomass** (Fig. 4) indices from RV surveys declined from the mid-1980s to the early-1990s, with both indices reaching time series lows in 1995. These indices varied at a low level until around 2003, and have been gradually increasing since then. The majority of the stock is located in Div. 3K, with an average of 51% of the survey biomass in this division from 1983-2017.

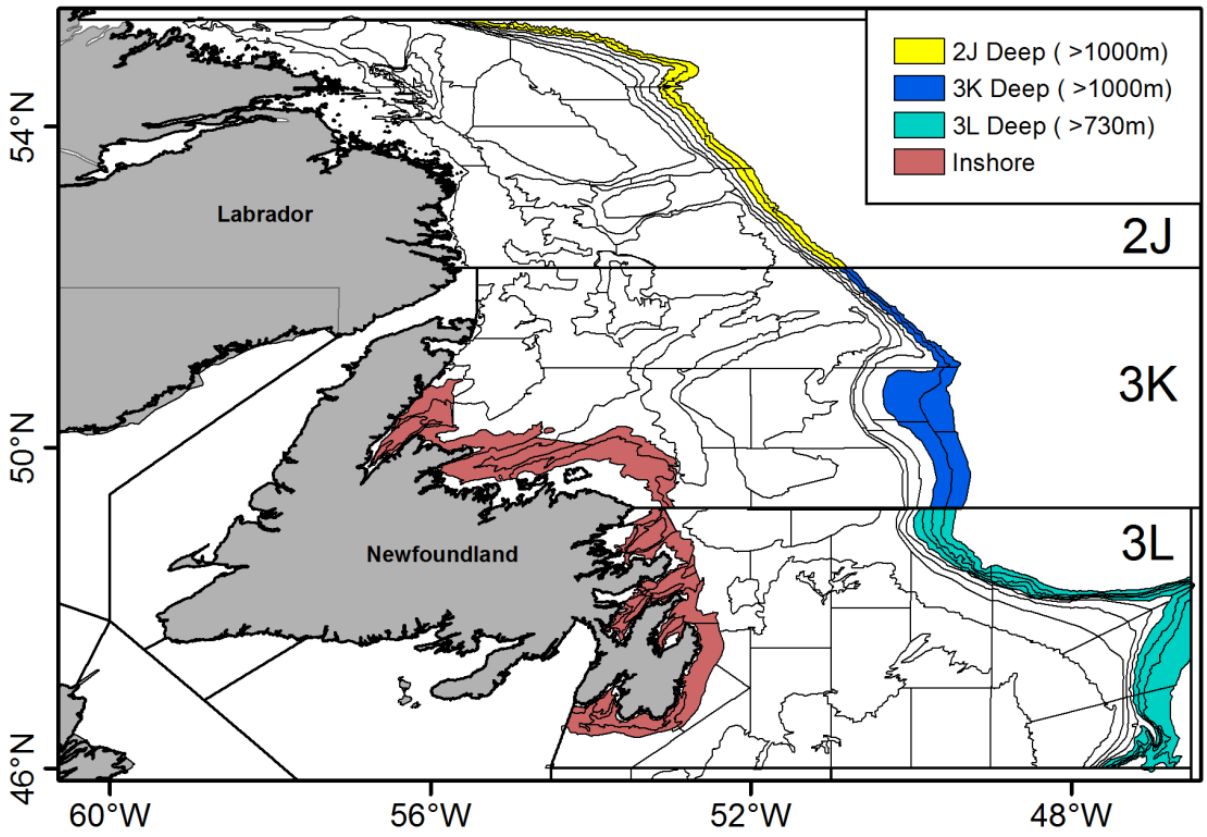

Figure 3. Map of survey stratification scheme for Divs. 2J3KL highlighting inshore (added in 1996) and deep (>1,000 m in 2J3K, >730 m in 3L) strata.

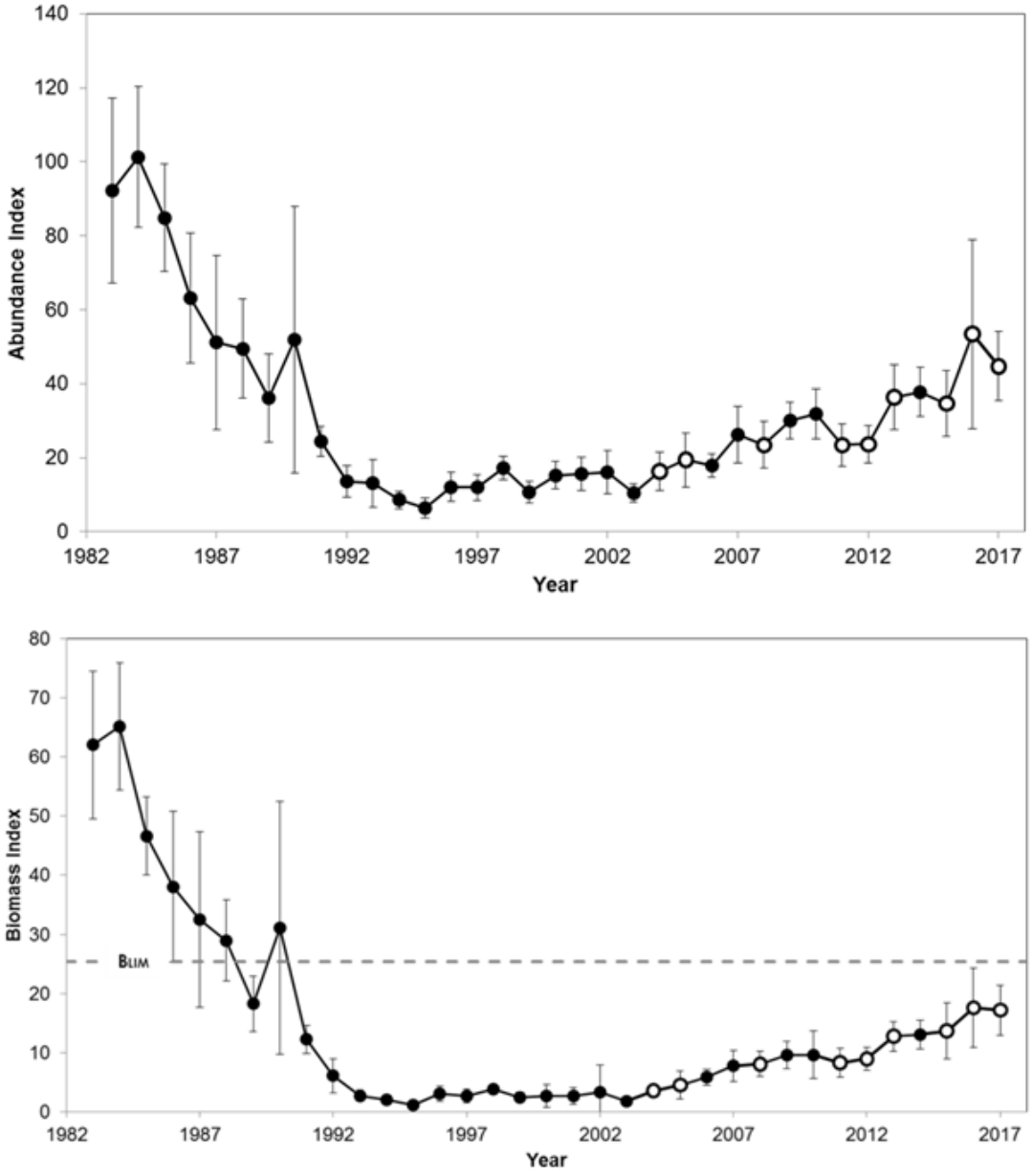

Figure 4. Abundance (top) and Biomass (bottom) indices from annual fall DFO RV survey in NAFO Divs. 2J3KL. Values are in Campelen equivalent units 1983-1995, and Campelen units from 1996-2017. Open circles indicate years where of 3L deep was not covered by the fall survey.

Historically, this stock was distributed along the shelf edge, into deep channels and to a lesser degree onto the banks of the Northeast Newfoundland Shelf and the Grand Bank. Following the decline of the stock through the late-1980s to early-1990s, the stock was largely restricted to the shelf edge. Recently, with increases in indices of biomass and abundance the distribution of survey biomass has been expanding back into these deeper channels and onto areas of the banks (Fig. 5).

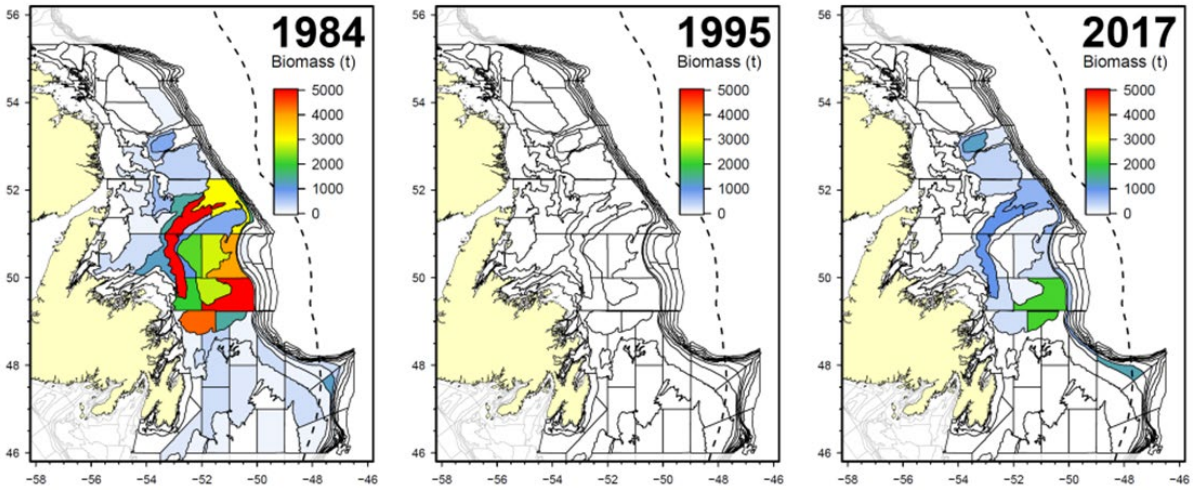

Figure 5. Distribution of Witch Flounder biomass by survey strata from DFO fall RV surveys, showing three representative years for pre-decline distribution (1984), time-series low biomass (1995), and present distribution (2017).

Recruitment trends were evaluated using indices of abundance of pre-recruit fish (<23 cm) from RV survey data (since the introduction of the Campelen trawl; 1995-2017). Given the presumed growth rates for this stock, multiple cohorts are considered to be included in each index value. Fish caught in the inshore strata (1996-98, 2000-06, 2010) in Divs. 3KL were almost exclusively within this pre-recruit size range, with an average of 90% of total inshore abundance in years where inshore strata were fully sampled. A portion of the pre-recruit abundance for this stock is therefore presumed to be missed by surveys in years when inshore strata are not sampled. In order to make values comparable among years with varying survey coverage, inshore strata have been excluded from the pre-recruit index. Pre-recruit indices are compared relative to the long term mean, with positive values indicating greater than normal recruitment (Fig. 6). A series of positive pre-recruit anomalies indicate improved recruitment since 2013, with a time series high in 2016.

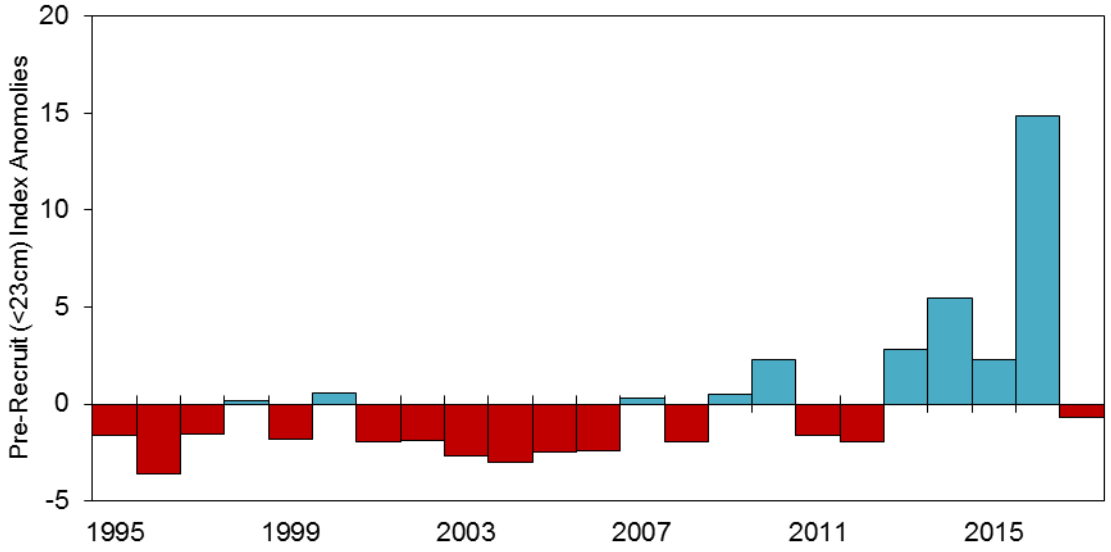

Figure 6. Pre-recruit (<23 cm) abundance index anomalies relative to the long-term mean.

Length composition from the RV survey is presented as abundance at length from fall surveys (Fig. 7). Witch flounder up to 55 cm were present in all surveys, with individuals up to 70 cm consistently in surveys prior to 1992, though rarely encountered in more recent times. At the beginning of the time series, length distributions were generally bimodal, with peaks near 26 cm and 45 cm. While populations were at their lowest levels from 1992 to 2003, few fish over 40 cm were present in the survey catches. Length distributions have returned to a multi-modal distribution in recent years, with an abundance of larger fish forming a group over 30 cm, and presumed cohorts entering at modes as low as 6 cm and tracking through the length frequencies year-over-year. Pulses of small fish in recent years are of a greater magnitude than earlier in the time series, and are consistent with above-average indices of pre-recruits described above. However, **age composition** is unavailable for this stock, and length data do not allow reliable tracking of individual cohorts through length frequencies. Numbers at length are expected to be composed of individuals from multiple cohorts.

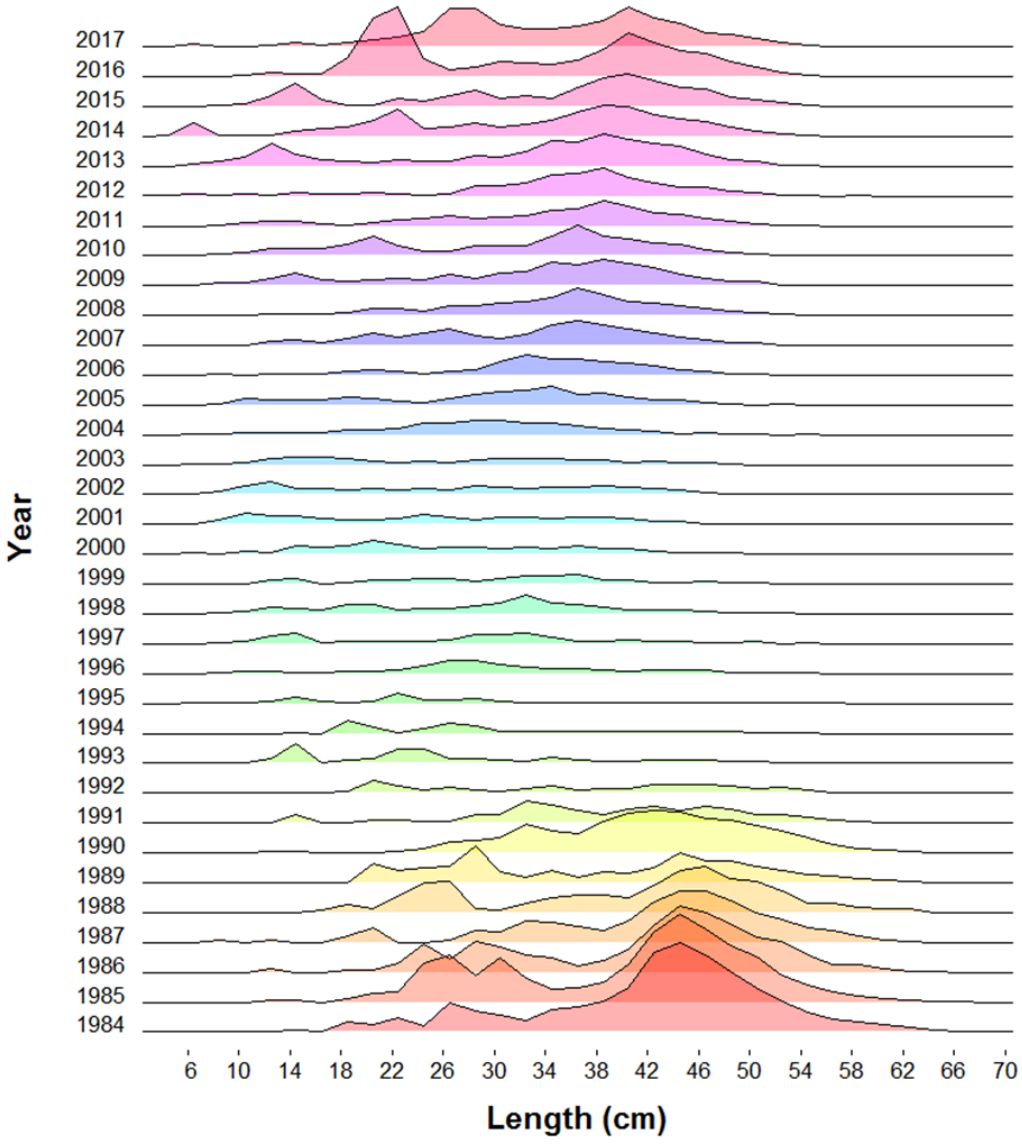

Figure 7. Length frequency of Witch Flounder captured during the fall RV survey in NAFO Divs. 2J3KL.

LIMIT REFERENCE POINT

A Limit Reference Point (LRP) within the DFO decision-making framework was set for Witch Flounder in NAFO Divs. 2J3KL based on survey biomass indices from the fall RV surveys. The survey index for the stock begins in 1983, as this is the point at which Campelen equivalent series of survey biomass and abundance are available for all three divisions within the stock. However, in Divs. 2J and 3K, Campelen-equivalent survey indices are available since 1977 and 1978, respectively (Fig. 8). Given that the bulk of the stock has historically been in Div. 3K, these earlier values provide information on trends in a major portion of the stock before the complete index was established. From 1978 to 1985, biomass index values for Divs. 2J and 3K appear to have varied without trend, suggesting a relatively stable period of stock size. Similar stability was observed in Div. 3L from 1983-90. From 1979-91, annual landings were also relatively steady, with average catches near 4,000 t (range: 2,800 to 4,900 t).

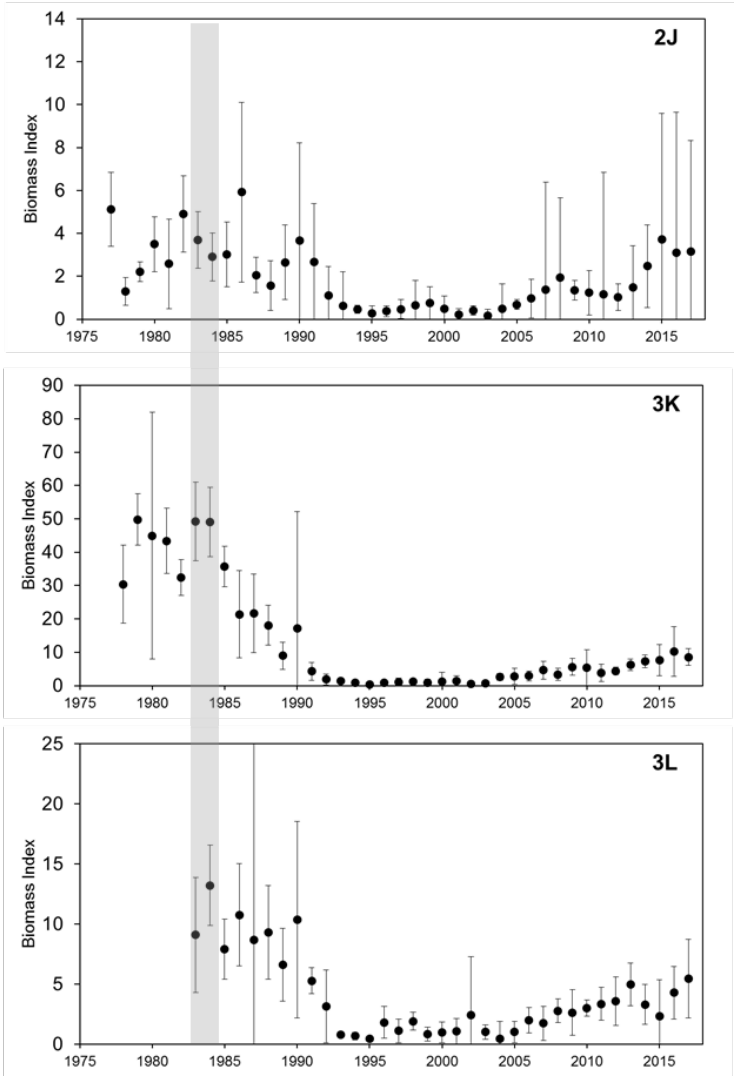

Figure 8. Survey biomass indices, by NAFO Division, since the start of the Campelen equivalent series in Divs. 2J (1977-2017), 3K (1978-2017), and 3L (1983-2017). Grey bars indicate the 1983-84 period from which the LRP was defined.

Given the combined stability in biomass indices and annual landings from the late-1970s through the early-1980s (following the earlier peak in the fishery), the survey indices at the start of the combined time series are considered to be a proxy for a B_{MSY} level. This B_{MSY} proxy was therefore defined as the mean survey biomass from 1983-84. Consistent with the DFO decision-making framework incorporating the precautionary approach, an LRP of B_{LIM} = 40% B_{MSY} was adopted.

However, it should be noted that the true B_{MSY} for this stock is likely to vary from this proxy value, though it cannot be determined given the current data available and the survey index based assessment of the stock.

Sources of Uncertainty

Aging data are unavailable for this stock since 1994. This precludes the use of any age-based analytical assessment methods. Individual cohorts cannot be reliably tracked through length frequency information.

Varying **survey coverage** within the fall RV survey throughout the time series introduces uncertainty into the indices; biomass and abundance indices are likely to be underestimated in a number of years, given the lack of sampling in some areas. Changes to survey coverage can be generally divided into considerations of (1) the inshore strata (fully sampled 1996-2005 and 2010, 1999 excluded), and (2) deep water strata (introduced in 1996, but with recent poor coverage of 3L deep). These changes in coverage are expected to have impacts on survey indices and the LRP, though the magnitude of these impacts cannot be fully determined.

1. ***Inshore strata***: In years sampled, the inshore strata have contributed a significant proportion of the abundance for this stock, with an average of 14.2% (maximum 27.6%) of total survey abundance located in these inshore strata. Most Witch Founder caught in the inshore were pre-recruits (<23 cm). In years where inshore strata are not sampled, the survey is likely to be missing a portion of the pre-recruit abundance; however the magnitude of this is unknown and may also be impacted by recent shifts in stock distribution. A small portion of the total survey biomass was located in the inshore strata in years sampled (average 2.0%, maximum 4.1%), reflecting the small size of fish caught in the inshore. A lack of inshore strata coverage in recent surveys is therefore not expected to impact perception of stock status relative to the LRP.
2. ***Deep strata***: The deep strata (>1,000 m in 2J and 3K, >730 m in 3L) were introduced to the RV survey in 1996. In Divs. 2J and 3K, there has been negligible Witch Flounder biomass (average of <1% of survey biomass since 1996) in strata >1,000 m, with none caught in these strata since 2011. The absences of these strata from the start of the time series are therefore not considered to impact survey indices from that time period, or impressions of current stock status relative to the LRP.

   The deep strata in 3L (>730 m) were consistently covered from 1996-2003, but have only been sampled in five years since (2006, 2007, 2009, 2010, 2014). A varying amount of total survey biomass has been located in 3L deep in years surveyed (Fig. 9), with up to 37% of the biomass index coming from these strata, but an average of 1% across the last five times surveyed. The proportion of the index located in Div. 3L deep was highest when the stock was at its lowest, and distribution largely restricted to the shelf edge. Survey data suggest that there is a small amount of Witch Founder biomass in the deep area of 3L, and while this amount is relatively steady, it accounts for a greater proportion of the index when the stock is at lower levels. Given recently observed increases in biomass indices and redistribution into deeper channels and onto the banks, 3L deep is likely of decreasing importance to

overall survey indices in this stock, though without recent survey coverage of these strata, this remains highly uncertain.

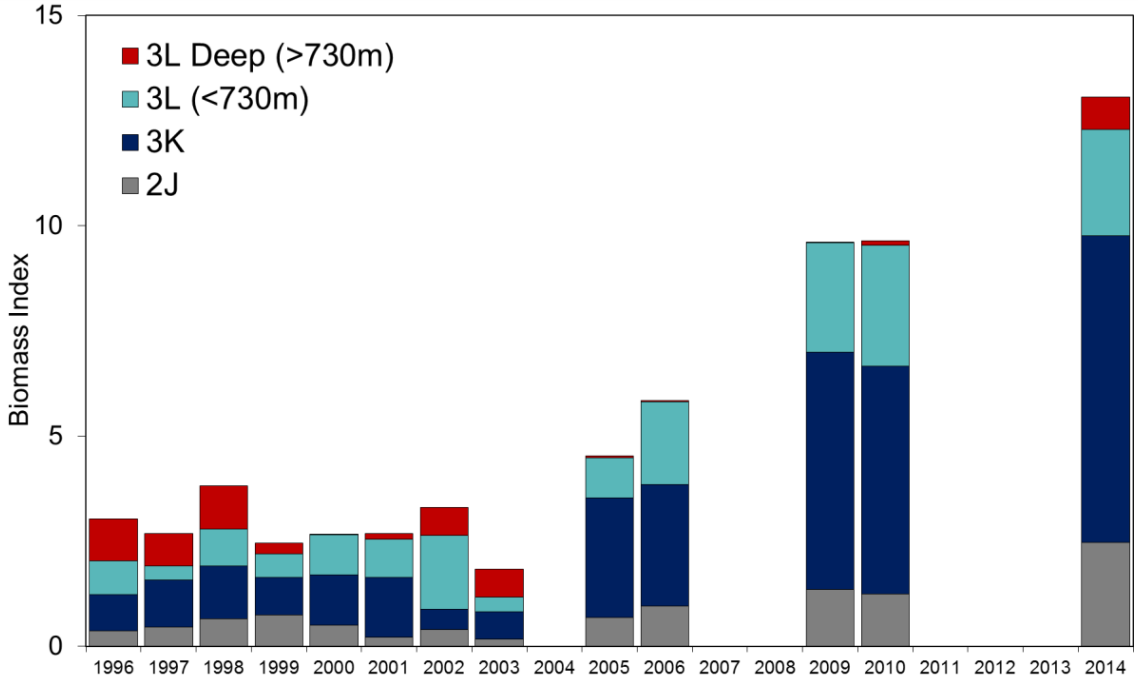

Figure 9. Biomass index by NAFO Division in years when 3L deep has been fully sampled, showing the portion of the index in the deep (>730 m) strata separate from the rest of the division.

CONCLUSIONS AND ADVICE

At the meeting, a LRP (B_{LIM}) was established for this stock based on indices of RV survey biomass. Despite increases in survey abundance and biomass since the early-2000s, and an observed expansion in distribution, the stock remains well below historic levels. Survey biomass has been consistently below the LRP since 1991, with the stock currently in the critical zone. Consistency with the DFO decision-making framework incorporating the precautionary approach requires that removals from all sources must be kept at the lowest possible level until the stock clears the critical zone.

MANAGEMENT CONSIDERATIONS

At this time it is not known with what frequency DFO Science will be requested to provide a full assessment of this stock. It is likely that the request will not be annual. In this case, stock status indicators will be examined during periods when there is no full assessment scheduled. Total biomass from the autumn DFO RV survey will be used as an interim year indicator of stock status. This index provides the basis for the assessment.

The 95% confidence intervals for the last fitted value of a smoother of the fall 2J3KL biomass index from 2002-17 will serve as the trigger for a new assessment (Fig. 10). In this approach, the interim year is year y. The average of the biomass index for y-2 to year y (in the first year from 2016-18) will be compared to the 95% confidence interval for 2017 from the smoother. If this average falls outside of the 95% confidence interval a new assessment will be conducted.

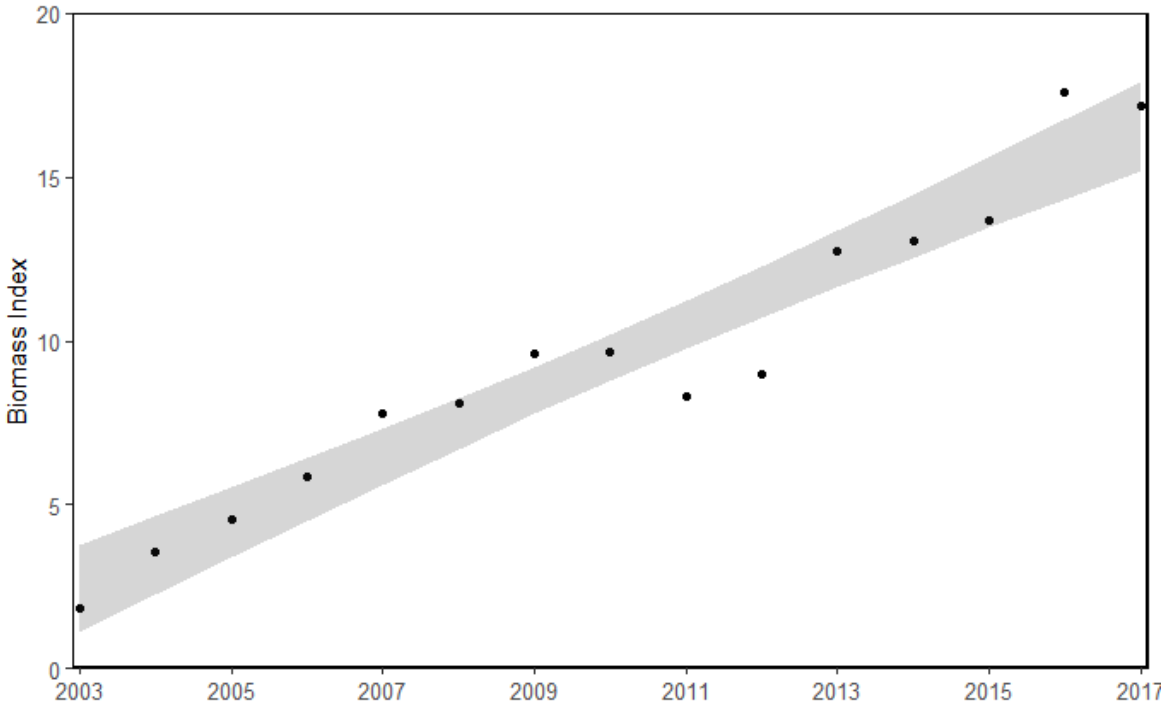

Figure 10. 95% confidence interval (CI) on a linear smoother of survey biomass indices from 2003 to 2017.

SOURCES OF INFORMATION

This Science Advisory Report is from the May 9, 2018 2J3KL Witch Flounder Stock Assessment. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Brattey, J., Cadigan, N.G., Dwyer, K., Healey, B.P., Morgan, M.J., Murphy, E.F., Parsons, D., and D. Power. 2008. Assessments of the cod (*Gadus morhua*) stock in NAFO Divisions 2J3KL (April 2007 and April 2008). DFO Can. Sci. Advis. Sec. Res. Doc. 2008/086.

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Rideout, R., D. Power, D.W. Ings, L.J. Wheeland, and B.P. Healey. 2017. Canadian multi-species bottom trawl surveys in NAFO subarea 2 + Divisions 3KLNOPs: Vessel performance, catch distribution and survey biomass trends of key finfish resources with emphasis on 2016. NAFO SCR Doc 17/044.

APPENDIX - LIST OF PARTICIPANTS

NAME	Affiliation
David Coffin	DFO-Resource Management
Julie Diamond	DFO-Resource Management
Erin Carruthers	Fish, Food and Allied Workers Union
Emma Cooke	Memorial University
Stan Oliver	NunatuKavut Community Council
Joanne Morgan	DFO-Science
James Meade	DFO-Centre for Science Advice-NL Region
Dawn Maddock Parsons	DFO-Science
Laura Wheeland	DFO-Science
Rick Rideout	DFO-Science
Karen Dwyer	DFO-Science
Bob Rogers	DFO-Science
Danny Ings	DFO-Science
Jenna Makrides	DFO-Science
Gillian Forbes	DFO Science
Jin Gao	Marine Institute
Noel Cadigan	Marine Institute
Bruce Chapman	The Groundfish Enterprise Allocation Council
Nancy Pond	Department of Fisheries and Land Resources - Government of Newfoundland and Labrador

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Centre for Science Advice
Newfoundland and Labrador Region
Fisheries and Oceans Canada
PO Box 5667
St. John's, NL
A1C 5X1
Telephone: (709) 772-8892

Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087

Correct Citation for this Publication:

DFO. 2019. Stock Assessment of Witch Flounder (*Glyptocephalus cynoglossus*) in NAFO Divisions 2J3KL. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/053.

Aussi disponible en français :

MPO. 2019. Évaluation du stock de plie grise (Glyptocephalus cynoglossus) dans les divisions 2J3KL de l'OPANO. Secr. can. de consult. sci. du MPO, Avis sci. 2018/053.